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VERTICAL AND HORIZONTAL INTRA-INDUSTRY TRADE: WHAT IS THE EMPIRICAL EVIDENCE FOR THE UK?

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1. *Introduction*

Since the pioneering contributions of Balassa (1966) and Grubel and Lloyd (1975) revealed a remarkable incidence of simultaneous exports and imports within industries (intra-industry trade) in the foreign trade structure of developed countries, a large body of academic work has expanded empirical and theoretical understanding of this phenomenon.

In recent years, important developments in the literature on intra-industry trade (IIT) have also stressed that a meaningful distinction - alongside the main opposition between intra and inter-industry flows - can be drawn between horizontal and vertical components in IIT. This distinction regards the nature of product differentiation. Whereas horizontal differentiation concerns alternative attributes of a particular traded good in a given quality level, vertical differentiation relates to alternative quality levels.

This conceptual specification is important because theoretical models have demonstrated that the forces underlying the two forms of product differentiation within IIT are not the same. Broadly speaking, in the case of vertical IIT, the dynamics of product differentiation (by quality) operate according to a Heckscher-Ohlin-type logic based on comparative advantages deriving from resource endowments and factor proportions; in the case of horizontal IIT,

the typical ingredients of imperfectly competitive market structures play the dominant role.

In spite of these clear indications of the theory, in almost all cases empirical studies investigating the determinants of IIT have not distinguished vertical from horizontal intra-industry trade. Only in recent years have some contributions tried to achieve better empirical assessment by adopting methodological procedures able to disentangle vertical and horizontal components in IIT.

Although the purpose of this recent empirical work has been to gain clearer understanding of the determinants of IIT, the distinction between vertical and horizontal differentiation in intra-industry trade indirectly yields better specification of the problem of international-trade-induced adjustment as well. Usually, the adjustment effects attributed to IIT are judged to be less severe than those associated with inter-industry trade because IIT is considered to be a two-way trade in similar goods between countries with similar factor endowments. This interpretation of IIT originates from monopolistic competition models of international trade in which traded goods are horizontally differentiated. But if we assume that vertical differentiation prevails in intra-industry trade, the terms of the problem change. For example, in the case of trade impact on labour markets, it is reasonable to suppose that differences in product quality are associated with differences in skill content, so that high (low) quality goods should incorporate a high (low) content of skilled labour. If the above relationship holds, it is evident that the impact of IIT on labour markets will be less neutral in the presence of vertical differentiation¹.

Recently, Greenaway, Hine and Milner (1994, 1995; henceforth G-H-M) - following the work of Abd-el-Rahman (1991) - have developed a methodology able to single out the share of vertical and horizontal IIT in the unadjusted Grubel-Lloyd index measured for each 3-digit industry by using information deriving from unit values calculated at the 5-digit level. G-H-M used this procedure to carry out separate econometric tests for the two components of IIT in the case of the UK, focusing on a range of industry and country

¹ In his recent book on North-South trade, Adrian Wood (1994) warns against understating the effects of trade on labour markets if product heterogeneity is not considered adequately. Indeed, more careful attention to the role played by vertical differentiation in trade is merely another way of taking up Wood's suggestion.

determinants of IIT.

According to G-H-M, discriminating between vertical and horizontal IIT improves the interpretation of empirical results. For instance, the previous empirical literature on industry-specific determinants of IIT *a priori* considered the tested negative link between the minimum efficient scale and total IIT (in conjunction with the tested positive relationship between the number of firms and total IIT) to be a result which supported the “large numbers” paradigm in which horizontal IIT is the predominant type. By contrast, G-H-M have demonstrated that in the case of the UK (in 1988): (i) vertical IIT is the most important component; (ii) vertical IIT fits the large numbers model better than horizontal IIT; (iii) the proxy variable for quality differentiation shows a significant link with vertical IIT, while the proxy variable for attribute differentiation is not significantly related to horizontal IIT.

Overall, G-H-M’s work suggests that the approach which distinguishes vertical from horizontal IIT is worth pursuing, given that it enables more accurate interpretation of empirical results. Nevertheless, the evidence reported for the two components of IIT in the case of the UK is not conclusive, since it depends closely on the source of the data, the level of disaggregation of products, and the criteria adopted to define the methodology.

This paper takes G-H-M’s methodology as its starting point to conduct further investigation of horizontal and vertical IIT in the UK (in 1990). It introduces two innovative features with respect to the G-H-M approach.

Firstly, unit values are computed using trade data at a very high level of product disaggregation (8-digit as compared to the 5-digit level adopted by G-H-M) in order to obtain a non-distorted proxy for prices (and consequently for quality differentiation).

Secondly, the share of vertical differentiation in IIT is further divided into two components (which are separately tested): the part of vertical IIT composed of flows in which the quality of exports is higher than the quality of imports; the remaining part formed by flows in which exports appear to be downgraded in comparison with imports. As shown below, this further distinction yields more coherent specification of the expected relationship between the proxy variable for quality differentiation and vertical intra-industry trade.

The paper is organized as follows. The next section discusses the difference between horizontal and vertical product differentiation, conducting a rapid survey of the theoretical literature on IIT. Section 3 describes the empirical methodology based on unit values of exports and imports used to distinguish vertical from horizontal intra-industry trade. Section 4 illustrates an econometric test for the industry-specific determinants of UK IIT, giving details on data, definition of variables, statistical specification and results. The final section makes some concluding remarks.

2. *Horizontal and vertical product differentiation in intra-industry trade*

2.1. To date, most of the literature on intra-industry trade has tended to assume that product differentiation is a horizontal phenomenon; that is to say, differentiation is based on product attributes rather than on differences in quality.

The horizontal differentiation hypothesis prevails in the IIT literature because intra-industry trade has generally been represented as a pattern of trade peculiar to developed countries. In other words, it has been conceived as two-way trade between economies similar in technology, factor endowments and (high) income levels. The empirical evidence has given quite broad support for this representation².

From a theoretical point of view, the use of a malleable device like the Chamberlinian monopolistic competition model has also contributed to the explanation of IIT in terms of horizontal product differentiation³. By extending Dixit and Stiglitz's (1977) closed economy model to the international context, Paul Krugman (1979) - *inter alia* - demonstrates that the interaction between economies of scale and horizontal product differentiation may be an inde-

² See Greenaway and Milner (1989).

³ Chamberlinian trade models can be found in: Krugman (1979, 1981), Lancaster (1980), Dixit and Norman (1980), Helpman (1981), Ethier (1982).

pendent cause of international trade (in the form of IIT) between countries which do not differ in technology or factor endowments. The assumptions of Krugman's model are straightforward. On the supply side, industry consists of a large number of firms, each producing a particular variety of the product under conditions of increasing returns. On the demand side, individuals appreciate variety in itself, and any new differentiated good available in the market is bound to enter the consumer's basket. In autarky, in each country, the range of varieties available to consumers and the full exploitation of economies of scale are both constrained by the size of the market. In these circumstances, it is evident that international trade may improve the trade-off between varieties and scale economies by creating a larger integrated market in which intra-industry specialization dynamics between countries enable firms to reduce unit costs, and in which access to a larger number of varieties increases consumer welfare.

The most obvious candidates for the horizontal IIT mechanism described by Krugman's model are countries with similar factor endowments and similar (high) income levels. In fact - in a Linder-type perspective where demand structure is associated with income level - it is reasonable to expect that the exchange of distinct varieties of the same product will be higher between such countries than it will be between trade partners differing in factor endowments and income levels. An important implication here is the less painful adjustment effects of horizontal IIT dynamics compared with inter-industry trade: if expanding and contracting sectors have similar factor intensities (in an IIT setting), resource reallocation between these sectors will be easier, and wage and price adjustment will be smaller⁴.

⁴ The idea of smoother allocative and distributional effects of IIT compared to inter-industry trade does not emerge in the 1979 version of Krugman's model because each national economy is identically modelled with one industry and one factor (undifferentiated labour). In this context, the better condition of workers-consumers under free trade is an obvious result, given the increasing return hypothesis. But in a subsequent version of Krugman's model (1981), the different adjustment effects between horizontal IIT and inter-industry trade are explicitly discussed. In this new framework, the supply side is modelled in a more articulated manner with a national economy consisting of two industries, each employing a specific type of labour (which is non-specific among varieties within an industry). By means of a very simple and compact formulation, Krugman shows the

2.2. Intuitively, the idea of painless IIT dynamics becomes weaker if the character of product differentiation is vertical - that is to say, if products differ in quality. In fact, the assumption of factor endowment similarity between countries is less plausible in a context of vertical IIT, where it is quite probable that differences in product quality will imply differences in factor content. Recently, the growing importance of IIT also in trade flows between advanced nations and developing countries has induced a rethinking of the usual image of IIT as a two-way trade in horizontally differentiated products, and it has stimulated the development of models of vertical intra-industry trade⁵.

By extending the pioneering work of Falvey (1981), Falvey and Kierzkowski (1985; henceforth F-K) show the existence of two-way trade in vertically differentiated products without resorting to imperfect competition and increasing returns. The competitive structure of the F-K model incorporates both Ricardian and Heckscher-Ohlin-type characteristics.

The supply side of each economy is modelled with two sectors, one (Ricardian) producing a single homogeneous good and the other (of Heckscher-Ohlin type) manufacturing different qualities of the same product. Both sectors employ labour, capital is specific to the sector producing the multiquality product, with capital intensity positively correlated with the "quality intensity" of the differentiated product.

On the demand side, consumers have the same preferences, and the demand for each quality, given relative prices, depends on

existence of a one-for-one positive relationship between the parameter indicating factor endowment similarity (among countries) and the Grubel-Lloyd IIT index. Subsequently, he analyzes the effect of trade on welfare by using an utility function in which utility depends on real wages and variety. Krugman demonstrates that both factors gain from trade when trading partners are similar in factor endowments (and consequently IIT prevails over inter-industry trade). Although this result is closely connected with the specific functional forms adopted in the model, Krugman's contribution of 1981 should be noted as one of the few attempts to model the proposition that IIT adjustment effects on domestic economy are less severe than inter-industry trade effects.

⁵ Vertical intra-industry trade models have been proposed by Falvey (1981), Shaked and Sutton (1984), Falvey and Kierzkowski (1985), Flam and Helpman (1987). Empirical evidence on North-South intra-industry trade is provided in Balance, Forstner and Sawyer (1992) and Tharakan and Kerstens (1995).

an individual's income: a higher level of income is associated with demand for a higher quality product. On the reasonable assumption of an uneven distribution of aggregate income among consumers, demand for different qualities of product will emerge in the economy, and the range of qualities demanded will depend on income distribution.

Under the above assumptions, the actual pattern of trade - with particular reference to the extent and character of vertical intra-industry trade - depends on the relative influence of the three sources of country differences: factor endowments, technology, and pattern of income distribution.

The spectrum of relevant cases presented by F-K is very broad, and in some circumstances model outcomes are indeterminate. However, in the present context, two main results are worth recalling: one deriving from H-O assumptions and the other arising from Ricardian hypotheses.

- 1) Assuming identical technologies but different factor endowments, the pattern of inter-industry trade is clearly determined: the capital-abundant country will be an importer of the homogeneous good and a net exporter of the differentiated product⁶.
- 2) Assuming identical factor endowments but different technologies, the pattern of vertical IIT is determinate: the country with superior technology in the homogeneous good sector will tend to export high quality products and to import low quality goods⁷. In this case, with no divergence emerging in per cap-

⁶ In this setting, vertical IIT may or may not take place. Moreover, even if IIT occurs, the pattern of IIT in terms of the quality of traded goods is indeterminate. In fact, although the capital-abundant country has a relatively higher comparative advantage in superior quality production, this advantage may or may not be reflected in its exports. Paradoxically, if differences in factor endowments between the two countries are so pronounced as to determine large differences in their levels of per capita income, the abundant-capital country (the rich country) may concentrate its exports in lower quality products. In fact, a greater distance between the means of the two countries' equally shaped income distributions reduces their area of overlap, and the poor country will demand low quality products only. Obviously, different results are associated with different assumptions about the form of income distributions in the two countries.

⁷ In fact, in a context of non equalization of factor prices, the higher wage rate of the technologically advanced country will involve a lower capital rental, giving this country a comparative advantage in higher quality products.

ita income levels between trading partners, consumers in both countries will divide into two groups: a group of high income individuals buying high quality products from the superior technology country, and a group of low income consumers demanding low quality products from the inferior technology country.

The above results suggest the ability of the F-K model of vertical IIT to combine the Linder-type idea of the importance of the link between demand structure and income with the traditional sources of comparative advantages⁸.

2.3. An alternative way to deal with vertical differentiation in IIT has been suggested by A. Shaked and J. Sutton (1984, henceforth S-S).

S-S do not examine the interplay between vertical IIT and factor proportion (like F-K) but propose a framework in which attention concentrates mainly on the sensitivity of results to the specification of consumer preferences, in the tradition of product differentiation theory. In particular, they suggest an oligopolistic context in which the opening up of trade is associated with sharper price competition which forces some firms (producing low-quality goods) to abandon the market.

Essentially, the focus of S-S's analysis is on the conditions under which the number of firms existing at Nash equilibrium is bound and independent of the extent of the economy. On the demand side, the willingness to pay for a higher quality product is positively correlated with consumer income. On the supply side, quality improvements are imputable to fixed costs (R & D expenditure), while unit variable cost rises only slowly with quality. Hence all consumers rank goods in an increasing order of quality at unit variable cost. In these circumstances, according to the finiteness property developed by S-S, the number of firms coexisting at equi-

⁸ As regards the adjustment problem, the implications of the F-K model are clearly different from those of horizontal IIT models. Unlike horizontal diversification, vertical product differentiation requires different factor intensities. Consequently, the dynamics of vertical specialization induced by international trade will imply more serious reallocative and distributional effects than those of horizontal IIT. Note that in the F-K model each quality is associated with a particular capital-labour ratio. The logic of the model does not change if the specific factor is embodied in skilled labour instead of capital.

librium is limited. Independently of industry size and of the product set, this result is due to a price competition mechanism: the rivalry among firms producing higher quality goods reduces their prices to a level where all consumers are agreed on buying their products, forcing the lower qualities out of the market. In this oligopolistic equilibrium with a limited number of firms, the opening up of trade does not create a tendency towards the atomistic situation envisaged by monopolistic competition models with horizontal differentiation. On the contrary, the market enlargement associated with free trade induces the exit of firms, given that the initial constraint on the number of units coexisting at equilibrium remains. In the long run, higher returns on R&D investment - in a setting of enhanced economies of scale - will induce the surviving producers to improve their product quality. In this context, the gains from trade for consumers arise from the availability of higher quality goods at lower prices.

3. Methodology

3.1. As noted earlier, from a theoretical point of view the explanatory factors of vertical IIT (VIIT) differ from the causes of horizontal IIT (HIIT). Therefore, separate econometric specification for each of the two forms of intra-industry trade may yield more discernible results in empirical tests on IIT determinants. However, a preliminary problem to solve is how to discriminate between the two types of IIT in empirical data.

Among recent contributions which develop an empirical methodology able to disentangle vertical and horizontal IIT, two main approaches have emerged in the literature.

The first is associated with the works of Abd-el-Rahman (1984), Freudenberg and Muller (1992) and CEPII (1995). This method is not based on Grubel-Lloyd index. It instead adopts a minimum threshold of overlap in trade (10%) to establish whether both exports and imports of a particular product represent either two-way trade or one-way trade. In addition, assuming that differ-

ences in unit values signal quality differences, traded goods are defined as vertically (horizontally) differentiated if unit values of exports and imports differ by more (less) than a certain range of variation ($\pm 15\%$). When applied to each product, these two criteria (defined at the more disaggregated level) allow total trade to be divided into three categories: (i) two-way trade in vertically differentiated products (overlap and high unit value differences); (ii) two-way trade in horizontally differentiated products (overlap and low unit value differences); (iii) one-way trade (low overlap).

The second method is the Greenaway, Hine and Milner approach (1994, 1995). These authors - following the work of Abd-el-Rahman (1991) - decompose the unadjusted Grubel-Lloyd (G-L) index into vertical and horizontal IIT by using information deriving from unit values calculated at the 5 digit level (according to SITC). The two components of IIT are discriminated by including in the numerator of the G-L index only the trade flows of those product categories whose unit value of exports relative to the unit value of imports is outside (or within) a certain range of variation ($\pm 15\%$). Where the absolute value of the difference between the unit values for exports and imports is more (less) than 15%, the share of vertical (horizontal) IIT is obtained.

In sum, both approaches use unit values in conjunction with an arbitrary dispersion criterion to infer the nature of product differentiation in IIT. But at the same time they adopt two different notions of trade overlap. In the first case, independently of the *extent* of the overlap, exports and imports are both considered to be part of either two-way trade or one-way trade, according to the 10% threshold criterion. In the second case, following the G-L tradition, the *intensity* of trade overlap is measured.

In practice, the first method is mainly concerned to draw the relevant demarcation line between *trade types*, rather than within the majority flow (as in the G-L indicator). As stressed by the authors, this approach avoids the ambiguity that arises from considering the majority flow as simultaneously intra- and inter- in nature.⁹

⁹ Assume that the majority flow is 200 and the minority flow 100. The GL index calculates the overlap (100+100) in total trade (300); therefore it is equal to 66%. Evidently, according to the GL method, the majority flow is both intra- and inter- in nature. The alternative method, given that the minimum threshold of overlap (10%) is attained, would consider both flows (200+100) to be intra- in

It also admits the possibility of recording a surplus of a deficit in the case of IIT as well, contrary to the G-L index¹⁰. Obviously, it cannot answer the specific question of the degree of overlap in trade¹¹.

3.2. On the basis of the second method discussed above, Greenaway Hine and Milner (1995) have tested industry-specific determinants of horizontal and vertical IIT across industrial sectors of the UK. They start from the theoretical literature by reconstructing a taxonomy of IIT models with particular regard to market structure characteristics. G-H-M's preferred explanation of HIIT is a Krugman-style monopolistic competition model with many firms, while there are alternative models which give rise to VIIT: Falvey and Kierzkowski's monopolistic competition model, and Shaked and Sutton's small numbers oligopoly model.

These three cases are tested by means of two different linear equations: one for HIIT, with univocal expected signs for regressor coefficients; the other for VIIT, with double expected sign for some variables, the direction of the sign depending on what model of VIIT predominates.

Two explanatory variables are included in both equations: a proxy for scale economies (output per firm) and a proxy for the level of competitiveness in industry (number of firms). In the HIIT equation, the expected sign is negative for the first regressor and positive for the second: a smaller minimum efficient scale of production and a larger number of firms are associated with more varieties, and consequently with a higher share of horizontal IIT. In the VIIT equation the expected signs are ambiguous, for the reason already mentioned.

Conversely, two independent variables are equation-specific. In the HIIT equation, the number of 5-digit SITC products in each industry is assumed to be the proxy variable for horizontal differentiation; the expected sign for the coefficient associated with this regressor is positive. In the VIIT equation, the share of non-manual workers in total employment is the proxy variable for vertical differ-

nature.

¹⁰ This makes it possible to distinguish situations in which comparative advantages play a significant role in IIT.

¹¹ Furthermore, the first method adds a further element of arbitrariness represented by the choice of overlap threshold to the dispersion criterion for product differentiation.

entiation; also in the case of this variable, the expected sign of the coefficient is positive.

The results of G-H-M regressions show that: (i) VIIT is associated with the large numbers model, while HIIT is better explained by the small numbers model¹²; (ii) the proxy variable for quality differentiation displays a significative and positive link with vertical IIT, while the proxy variable for attribute differentiation is not significantly related to horizontal IIT.

The G-H-M outcome is important because it demonstrates that separate analysis of the two components of IIT challenges the interpretation yielded by the earlier evidence on the determinants of *total* IIT; in particular, it challenges the idea that the large numbers model of horizontal IIT is the most important explanatory paradigm. Nevertheless, the evidence reported by G-H-M for the UK is not conclusive, since it depends closely on the data utilized, the level of disaggregation of product categories, and the methodological criteria adopted. In this regard, two critical observations are worth raising about G-H-M's work.

The first is straightforward: if unit values are used to deduce quality differentiation, they must be related to an unambiguously defined product. In other words, a very high level of disaggregation must be adopted in order to eliminate problems of sectoral composition. Probably, the 8-digit degree makes this possible; in fact, at this stage, products are so tightly defined that UV differences are a real indicator of quality. By contrast, 5-digit groups (the level assumed by G-H-M) are quite heterogeneous¹³.

The second observation is more problematic and concerns the

¹² The number of firms has a negative (positive) coefficient in the HIIT (VIIT) equation.

¹³ An illustrative example can clear up this point. The 4-digit code 6103 of CN indicates an heterogeneous group of clothing products including men's suits, ensembles, jackets, blazers, trousers, bib and braces, etc. The 5-digit code 61034 indicates a more restricted set of products; however, this set is still quite heterogeneous: trousers, breeches, bib and braces made of wool, of cotton, of synthetic fibres, etc. The 8-digit code 61034999 indicates men's brace of textiles materials. Suppose that the 5-digit level is adopted; in this case, a UV differences might reflect trousers being exported and braces imported; which means that UV differences are not a reliable indicator of vertical differentiation. By contrast, if the 8-digit level is adopted, UV differences would properly signal quality differences between braces exported and braces imported.

relationship between VIIT and the explanatory variable for vertical differentiation. As mentioned above, the share of non-manual workers in total industry employment is considered to be the proxy variable for quality differentiation. In other words, this variable can be interpreted as the ratio of skilled to unskilled workers (SKUN). Considering that product quality reflects skill content, G-H-M expect industries with a higher content of non-manual (skilled) workers to be associated with a higher share of VIIT.

However, there is an implicit element of indeterminateness in G-H-M's specification of the relationship between the proxy variable for vertical differentiation (SKUN) and VIIT. In fact, while the variations in the SKUN variable indicate a precise direction of skill intensity across industries, the variations in the VIIT variable only indicate different shares of vertical product differentiation in intra-industry trade, without specifying which flow has the higher unit value. Hence, in principle, a high value of VIIT may be associated with the dominance of exports whose quality is lower than the quality of imports; in this case, the expected sign of the regression coefficient should be negative. In effect, we would expect the F-K model to show that VIIT is related to the *variation* in SKUN within a sector *and* the differences in skill endowments between countries¹⁴. Even if we assume that the UK is more skill-rich than its trading partner¹⁵, it is not obvious that high SKUN sectors will be the ones in which UK products are most differentiated in quality (either upwards or downwards). Only if VIIT is further qualified in order to distinguish which flow incorporates the higher quality is it possible to arrive at a determinate relationship. Suppose that VIITUP (VIITDO) is the part of VIIT composed of flows where UK exports appear to be upgraded (downgraded) in comparison with imports. In this case, continuing with the assumption that the UK is skill-rich, we would expect VIITUP to be positively associated with SKUN, and VIITDO to be negatively associated with SKUN; and if the assumption concerning UK endowments is wrong, the sign should go the other way.

¹⁴ E. Leamer (1984) has suggested that, to explain trade flows, information is required on both the factor endowments of countries and the factor intensities of production.

¹⁵ This assumption is implicit in G-H-M's specification of the relationship between VIIT and SKUN.

In this paper, G-H-M's methodology is refined in accordance with the two critical observations discussed above, the purpose being to conduct further investigation of horizontal and vertical IIT in the UK (in 1990). In comparison with G-H-W's work, two novel features are introduced. Firstly, unit values are computed using trade data at a very high level of product disaggregation (8-digit as opposed to the 5-digit level adopted by G-H-M) in order to obtain a non-distorted proxy for prices (and consequently for quality differentiation). Secondly, the share of vertical differentiation in IIT is further divided into two components, which are tested separately: the part of vertical IIT composed of flows in which the quality of exports is higher than the quality of imports (VIITUP); the remaining part formed by flows in which exports appear to be downgraded in comparison with imports (VIITDO). As discussed above, this further distinction helps to solve the indeterminateness problem associated with the relationship between the proxy variable for quality differentiation and vertical intra-industry trade.

3.3. Before illustrating the results of the regression analysis proposed in this paper, brief discussion is advisable of the methodology used to divide IIT into its components.

If i indicates a particular 3-digit level industry and c denotes all 8-digit level product categories in industry i , the (Grubel-Lloyd type) IIT index referred to industry i is:

$$(1) \quad IIT_i = 1 - \frac{\sum_c |X_{ic} - M_{ic}|}{\sum_c (X_{ic} + M_{ic})}$$

where X_{ic} and M_{ic} indicate the value of exports and import respectively.

In order to divide IIT_i into its vertical and horizontal components, unit values (UV) of exports and imports can be used to collect information about the quality of traded goods. In the literature, the controversial aspects of employing UV as a proxy for prices are well-known, but in the present context, considering that UVs are referred to 8-digit level categories, the risk of distortions caused by aggregation does not arise.

Index (1) can be rearranged as:

$$(1b) \quad IIT_i = \frac{\sum_c (X_{ic} + M_{ic}) - \sum_c |X_{ic} - M_{ic}|}{\sum_c (X_{ic} + M_{ic})}$$

The numerator of index (1b) can be recalculated by considering only those categories in i where the absolute value of the difference between the UV for exports and imports is greater than 20%; that is: $1.20 < UVX_{ic}/UVM_{ic} < 0.80$.¹⁶

Consequently, index (1b) becomes the share of vertical intra-industry trade in total trade with reference to industry i :

$$(2) \quad VIIT_i = \frac{\sum_{c_v} (X_{ic_v} + M_{ic_v}) - \sum_{c_v} |X_{ic_v} - M_{ic_v}|}{\sum_c (X_{ic} + M_{ic})}$$

Clearly, the index (2), by definition, does not specify which flow (export or import) has the higher UV. As shown above, this indeterminateness of index (2) implies an ambiguous relationship between the explanatory variable for vertical differentiation and vertical intra-industry trade. To eliminate this ambiguity, it is sufficient to divide the index (2) into two parts to be tested: the part composed by those products where exports are qualitatively upgraded compared with imports, the remaining part formed by those goods where exports are downgraded.

In other words, if the numerator of index (2) is recalculated considering only those categories in i where the difference between the UV for exports and imports is greater than 20% ($UVX_{ic}/UVM_{ic} > 1.20$), the share of up-market vertical intra-industry trade in total trade is obtained:

$$(2a) \quad VIITUP_i = \frac{\sum_{c_{vup}} (X_{ic_{vup}} + M_{ic_{vup}}) - \sum_{c_{vup}} |X_{ic_{vup}} - M_{ic_{vup}}|}{\sum_c (X_{ic} + M_{ic})}$$

¹⁶ The dispersion criterion is obviously arbitrary. G-H-M adopt alternatively the 15% or the 25% criterion in their econometric test. In this paper a 20% criterion is adopted because, if a narrower range of variation were assumed, an excessive dominance of VIIT would emerge in all industries. As shown below, the significance level of results is influenced by the type of criterion used.

Alternatively, the share of down-market vertical intra-industry trade in total trade is computed by considering just those items in i where $UVX_{ic}/UVM_{ic} < 0.80$ in the numerator:

$$(2b) \quad VIITDO_i = \frac{\sum_{c_{vdo}} (X_{ic_{vdo}} + M_{ic_{vdo}}) - \sum_{c_{vdo}} |X_{ic_{vdo}} - M_{ic_{vdo}}|}{\sum_c (X_{ic} + M_{ic})}$$

Finally, the same procedure can be followed to obtain the share of horizontal intra-industry in total trade in industry i . In this case, the numerator of the index is calculated by considering the items where: $0.80 < UVX_{ic}/UVM_{ic} < 1.20$; that is, those residual categories where quality differences between exports and imports are not particularly pronounced. The resulting index is:

$$(3) \quad HIIT_i = \frac{\sum_{c_h} (X_{ic_h} + M_{ic_h}) - \sum_{c_h} |X_{ic_h} - M_{ic_h}|}{\sum_c (X_{ic} + M_{ic})}$$

Under the above assumptions, it is natural that:

$$(4) \quad IIT_i = VIIT_i + HIIT_i = VIITUP_i + VIITDO_i + HIIT_i.^{17}$$

4. Empirical evidence

4.1. In undertaking this study, the first problem to solve was collecting industry data compatible with trade data. The solution adopted was to use the INDE and COMEXT databanks, both of which provide EU country statistics.

INDE furnishes information about such industry variables as: employment, wages, units of production, turnover, value added, investments, etc. With reference to employment in particular, it enables

¹⁷ In fact, the numerator in (1b) is equal to the sum of numerators in (2a), (2b) and (3).

manual workers to be distinguished from non-manual workers.

COMEXT supplies data on trade flows: values and volumes of imports and exports.

Both databanks permit use of the same 3-digit level NACE classification; in other words, they furnish compatible data on 130 industrial sectors.

In addition, the COMEXT databank gives information about all the 8-digit level categories entering each 3-digit NACE sector. It is thus possible to calculate HIIT and VIIT indices for each 3-digit NACE sector by using the UV of exports and imports calculated at the 8-digit level according to the above methodology.

4.2. The above data made it possible to define the following variables for each 3-digit NACE sector (industry i).

IIT_i	= total intra-industry trade index in industry i ;
$HIIT_i$	= horizontal intra-industry trade index in industry i ;
$VIIT_i$	= vertical intra-industry trade index in industry i ;
$VIITUP_i$	= up-market vertical intra-industry trade index in industry i ;
$VIITDO_i$	= down-market vertical intra-industry trade index in industry i ;
SCA_i	= proxy for scale economies in industry i (turnover/units ratio);
$COMP_i$	= proxy for competitiveness in industry i (units);
$SUBSE_i$	= proxy for attribute product differentiation in industry i (number of 8 digit categories in each 3 digit NACE industry);
$SKUN_i$	= proxy for skill intensity in industry i (non manual workers/manual workers ratio);
$INNOV_i$	= proxy for innovation in industry i (investment/added value ratio);
KL_i	= proxy for capital intensity in industry i (investment/employment ratio);

These variables yield information about specific characteristics of industrial sectors. In particular, it is possible to distinguish three groups of variables. The first consists of the trade-specific dependent variables to test (IIT_i , $HIIT_i$, $VIIT_i$, $VIITUP_i$, $VIITDO_i$); the second of the explanatory variables associated with market struc-

ture (*SCA*, *COMP*, *SUBSE*); the last of “Eckscher-Ohlin-Ricardian type” variables (*SKUN*, *INNOV*, *KL*).

The variables in the second group are usually utilized as regressors in the empirical testing of the industry-specific determinants of total intra-industry trade. The following equation represents a typical form assumed by the models tested:

$$(5) \quad IIT_i = \alpha_0 + \alpha_1 SUBSE_i + \alpha_2 SCA_i + \alpha_3 COMP_i + e_i$$

In equation (5) the expected signs of the regressor coefficients are ambiguous because the dependent variable is total intra-industry trade. But if horizontal intra-industry trade is tested, the expected link between the dependent variable and the regressors is defined as univocal. In particular, if we replace *IIT* in (5) with *HIIT*, we now expect the sign of the coefficients to be: $\alpha_1 = +$, $\alpha_2 = -$, $\alpha_3 = +$.

As noted by G-H-M, this second formulation of equation (5) - instead of the first one - is more appropriate for testing the large numbers case of horizontal IIT.¹⁸

However, in the vertical intra-industry trade equation, the ambiguity of the signs of the coefficients remains:

$$(6) \quad VIIT_i = \alpha_0 + \alpha_1 SKUN_i + \alpha_2 SCA_i + \alpha_3 COMP_i + e_i,$$

where the expected signs are: $\alpha_1 = \pm$, $\alpha_2 = \pm$, $\alpha_3 = \pm$.

The ambiguity of the signs in (6) is not confined only to the two variables (*SCA* and *COMP*) which discriminate between the two possible cases of VIIT (small numbers and large numbers model); it also concerns *SKUN*, the specific variable for vertical product differentiation.

As discussed earlier, G-H-M attribute a positive expected sign to the link between *VIIT* and *SKUN* ($\alpha_1 = +$). More precisely, the direction of the relationship between these two variables must be considered ambiguous because *VIIT*, by definition, does not specify which flow (import or export) has the higher unit value.

¹⁸ The large numbers case is the most relevant model of horizontal IIT. The small numbers case is considered to be an exception in the literature. On this point, see Eaton-Kierzkowski (1984).

However - under a given assumption about the skill endowments of the country observed - it is possible to suppose an unambiguous sign for the link between vertical intra-industry trade and *SKUN* if the up-market and the down-market components of *VIIT* are tested separately. When *VIITUP* is tested in (6), instead of *VIIT*, the expected signs are: $\alpha_1 = +$, $\alpha_2 = \pm$, $\alpha_3 = \pm$; in the case of *VIITDO*, the expected signs of the coefficients are: $\alpha_1 = -$, $\alpha_2 = \pm$, $\alpha_3 = \pm$ ¹⁹.

4.3. In this paper, the equations illustrated above have been estimated for the UK in 1990 by carrying out standard OLS cross-section regressions on 67 observations (industrial sectors)²⁰. UK intra-industry trade has been analysed with regard to three geographical groupings: total trade, intra-EU trade and extra-EU trade. In the case of vertical intra-industry trade, two additional explanatory variables have been included in the basic estimated equation: the proxy for innovation in industry (*INNOV*) and the proxy for capital intensity in industry (*KL*).²¹

Total intra-industry trade

Table 1 illustrates the regression results with reference to total IIT. The general impression that emerges from this first set of regressions is that the previous evidence supporting the large numbers model of IIT is verified only in part. In all three equations tested, the negative coefficient associated with *SCA* in conjunction with the positive sign on *COMP* may indicate that a lower minimum efficient scale favours firms' access to market²². Yet this evidence is not particularly strong because only *COMP* emerges with a reli-

¹⁹ Under the hypothesis that the UK is a skill-abundant country.

²⁰ Some particular sectors, such as the extraction and chemicals industries, have been excluded from the number of observations, the reason being that these particular industries, being too capital-intensive, offer a distorted measure of skill-intensity.

²¹ *SKUN* is the only specific explanatory variable for vertical differentiation investigated by G-H-M. Yet, as discussed in section 2, in the Falvey-Kierzkowski model the "Eckscher-Ohlin-Ricardian type" variables *INNOV* and *KL* are crucial for explanation of vertical intra-industry trade.

²² The *COMP* coefficient shows a high and stable level of significance (1%) in comparison with the *SCA* coefficient. In this regard, Greenaway, Hine and Milner (1995) have obtained the opposite result.

able sign. Finally, the negative (but not very reliable) sign on *SUBSE* may indicate that attribute differentiation is not the most important element in *IIT*. This result contrasts with the traditional conviction - as it emerges from previous empirical studies - that horizontal intra-industry trade is the dominant form of *IIT*.

On the whole, this first set of regressions on *total IIT* yields an outcome reasonably in line with recent estimates by Greenaway, Hine and Milner (1995). Nevertheless, results departing from the evidence reported by G-H-M are obtained in the present paper when horizontal and vertical intra-industry trade are tested separately.

Tab. 1 - Industry-specific determinants of the UK total intra-industry trade in 1990 OLS regression results. Dependent variable is IIT. 67 observations ^(a)

Regressors	α_0	<i>SUBSE</i>	<i>SCA</i>	<i>COMP</i>	R^2 ^(b)
Expected sign		\pm	\pm	\pm	
1) Total trade	0.48 (12.79) [0.000]	-0.00050 (-1.692) [0.096]	-0.00040 (-1.813) [0.075]	0.00015 (3.055) [0.003]	0.19 (0.15)
2) Intra-EU trade	0.48 (13.44) [0.000]	-0.00057 (-2.005) [0.050]	-0.00015 (-0.738) [0.463]	0.00015 (3.328) [0.002]	0.18 (0.14)
3) Extra-EU trade	0.33 (8.709) [0.000]	-0.00040 (-1.318) [0.192]	-0.00052 (-2.278) [0.026]	0.00016 (3.273) [0.002]	0.23 (0.19)

(a) = t-ratio in round brackets; probability in square brackets. (b) = R-bar-squared in brackets.

Horizontal intra-industry trade

Table 2 displays the results associated with *HIIT* estimates. The only variable showing a satisfactory level of significance with the appropriate sign is *COMP*, the proxy variable for market structure. In particular, the positive sign on *COMP* seems to conform with the large numbers model of *HIIT* (e.g. monopolistic competition model).

It is important to note that this result contrasts with G-H-M's estimates for *HIIT*, where an unexpected negative sign on *COMP* was generated. In effect, in G-H-M this inappropriate sign on

COMP combined with an insignificant coefficient for *SUBSE* (the specific proxy for horizontal differentiation) induced them to consider the estimated equation for *HIIT* to be less robust than those for *IIT* and *VIIT*. Finally, G-H-M emphasized the superior capability of *VIIT* to explain the large numbers model of IIT.

Tab. 2 - Industry-specific determinants of the UK horizontal intra-industry trade in 1990

OLS regression results. Dependent variable is *HIIT*. 67 observations ^(a)

Regressors	α_0	<i>SUBSE</i>	<i>SCA</i>	<i>COMP</i>	R ² ^(b)
Expected sign		+	-	+	
1) Total trade ^(c)	-0.011 (-0.976) [0.923]	-0.011 (-0.623) [0.535]	0.017 (0.975) [0.333]	0.035 (2.152) [0.036]	0.07 (0.02)
2) Intra-EU trade	0.194 (6.771) [0.000]	0.000071 (0.313) [0.755]	-0.00014 (-0.8624) [0.392]	0.000011 (0.299) [0.766]	0.02 (0.03)
3) Extra-EU trade ^(c)	-0.064 (-0.744) [0.460]	-0.007 (-0.576) [0.566]	0.014 (1.089) [0.280]	0.027 (2.213) [0.031]	0.08 (0.03)

(a) = t-ratio in round brackets; probability in square brackets.

(b) = R-bar-squared in brackets.

(c) = Log of explanatory variables in estimated equation.

Vertical intra-industry trade

However, the *VIIT* estimates reported in this paper challenge the robustness of the G-H-M results. In particular, the methodological problem raised in the previous section concerning the appropriate direction of the link between *SKUN* and *VIIT* is confirmed by the regression results. Contrary to the G-H-M outcome, *SKUN* - the specific proxy for vertical differentiation - exhibits a negative sign (see regressions 1, 2, 3 in table 3).

As discussed earlier, this outcome is plausible because *VIIT*, by definition, does not specify which flow (export or import) incorporates a superior quality. In addition, a positive sign at a high level of significance is associated with *COMP*. This circumstance

seemingly supports the large numbers model of *VIIT*, although the unstable coefficients associated with *SCA* do not entirely bear out this interpretation. However, if *KL* and *INNOV* are inserted in the estimated equation for *VIIT*, the overall explanatory power of the equation improves, giving more solid support for the large numbers model (see regression 4 in table 3)²³.

Tab. 3 - Industry-specific determinants of the UK vertical intra-industry trade in 1990 OLS regression results. Dependent variable is VIIT. 67 observations ^(a)

Regressors	α_0	<i>SKUN</i>	<i>SCA</i>	<i>COMP</i>	<i>KL</i>	<i>INNOV</i>	R^2 ^(b)
Expected sign		±	±	±	±	±	
1) Total trade	0.317 (7.001) [0.000]	-1.333 (-1.61) [0.113]	0.00013 (0.531) [0.598]	0.00012 (3.076) [0.003]			0.18 (0.14)
2) Intra-EU trade	0.308 (13.44) [0.000]	-1.349 (-2.005) [0.122]	0.00029 (-0.738) [0.260]	0.00012 (3.328) [0.006]			0.14 (0.14)
3) Extra-EU trade	0.267 (6.044) [0.000]	-0.926 (-1.146) [0.256]	-0.00021 (-0.908) [0.367]	0.00013 (3.336) [0.001]			0.24 (0.20)
4) Extra-EU trade	0.213 (2.313) [0.024]	2.348 (1.659) [0.103]	-0.00055 (-2.325) [0.024]	0.00010 (2.926) [0.005]	-42.492 (-2.216) [0.031]	0.762 (0.884) [0.380]	0.38 (0.32)

(a) = t-ratio in round brackets; probability in square brackets.

(b) = R-bar-squared in brackets.

Table 4 shows a more accurate investigation of the relationship between product quality and skill intensity. As argued earlier, only if up-market vertical intra-industry trade (*VIITUP*) is tested in the place of *VIIT* can the expected sign on *SKUN* be unambiguously assumed to be positive²⁴.

²³ Note that in regression 4 (tab. 3) the *SCA* coefficient becomes negative and significant at the 5% level. In addition, the sign on *SKUN* becomes positive and *KL* shows a negative coefficient at the 5% level of significance, while *INNOV* coefficient is insignificant.

²⁴ Under the hypothesis that the UK is a skill-abundant country.

Tab. 4 - Industry-specific determinants of the UK up-market vertical intra-industry trade in 1990

OLS regression results. Dependent variable is *VIITUP*. 67 observations ^(a)

Regressors	α_0	<i>SKUN</i>	<i>SCA</i>	<i>COMP</i>	<i>KL</i>	<i>SUBSE</i>	R^2 ^(b)
Expected sign		+	\pm	\pm	+	-	
1) Intra-EU trade ^(c)	0.126 (1.198) [0.236]	1.488 (1.930) [0.058]	-0.042 (1.775) [0.081]	0.011 (0.799) [0.427]			0.09 (0.04)
2) Intra-EU trade	0.134 (4.170) [0.000]	1.272 (2.116) [0.039]		0.000065 (2.215) [0.031]	-15845 (-2.693) [0.009]		0.18 (0.14)
3) Intra-EU trade	0.186 (5.971) [0.000]		0.00026 (1.912) [0.061]	0.000094 (3.129) [0.003]	-9.991 (-2.217) [0.031]	-0.00040 (-2.210) [0.031]	0.24 (0.19)

(a) = t-ratio in round brackets; probability in square brackets.

(b) = R-bar-squared in brackets.

(c) = Log of *SCA* and *COMP* in estimated equation.

In effect, *VIITUP* estimates in the case of intra-EU trade confirm a positive sign on *SKUN* at the 5% level of significance. The comparison between this outcome and the opposite result shown in table 3 suggests that it is worthwhile separating *VIITUP* from *VIITDO*. In general terms, the separate testing of the upwards and the downwards components of *VIIT* makes it possible to infer the direction of comparative advantage with reference to the quality of products from the sign on *SKUN*.

With regard to the other explanatory variables, the negative sign on *SCA* in conjunction with a positive *COMP* coefficient lends support to the large numbers case.

If *KL* is introduced into the estimated equation - instead of *SCA* in regression 2 - R^2 improve²⁵. The resulting negative sign associated with *KL* (1% level of significance) in association with the positive sign on *SKUN* suggests that, as regards intra-EU trade, the UK has a comparative advantage in skill-intensive products, but it is at a

²⁵ Note that the Falvey-Kierzkowski-type hypothesis of a positive link between capital intensity and quality intensity is consistent with *VIITUP* but not with *VIIT* as dependent variable (in this latter case the above relationship would be ambiguous). This is a further reason for carrying out separate tests of *VIITUP* within *VIIT*.

disadvantage in capital-intensive products. This finding is quite plausible if we consider, for example, UK-German trade and Germany's strong comparative advantage in engineering products.

A final remark is in order concerning the sensitiveness of estimates to the dispersion criterion adopted to disentangle *HIIT* and *VIIT*.

As discussed in the previous section, the methodology proposed by G-H-M in order to divide *HIIT* from *VIIT* in trade data incorporates a procedure based on an discretionary element: the *ad hoc* definition of the range of variation for UV. G-H-M, after testing the robustness of econometric results by adopting two alternative criteria (15%, 25%), concluded that estimates remained substantially unchanged. However, their assessment of the dependence of empirical results on the choice of dispersion criterion appears too optimistic. In this regard, table 5 illustrates the variation of coefficients and t-ratios associated with the *SKUN* explanatory variable in the presence of different UV dispersion criteria.

The table shows that a less restrictive definition of *VIIT* (a narrower range of variation for UV) improves the level of significance of the *SKUN* coefficient. This finding suggests that the element of arbitrariness implicit in the *VIIT-HIIT* definition (dispersion criterion) does not seem to be neutral in terms of the empirical results.

Tab. 5 - Sensitiveness of the SKUN coefficient to the dispersion criterion in the basic estimated equation of vertical intra-industry trade (dependent variable is VIIT)^(a). UK intra-EU trade.

UV dispersion criterion	Coefficient of SKUN	t-ratio ^(b)
10%	-2.2174	-2.3456 (0.022)
15% (G-H-M definition)	-1.4981	-1.6290 (0.109)
20% (Our definition)	-1.3493	-1.5677 (0.122)
30%	-0.9231	-1.4199 (0.161)

(a) = See regression 2 in table 3.

(b) = Probability in brackets.

5. Conclusions

This paper has offered empirical evidence concerning the industry-specific determinants of UK horizontal and vertical intra-industry trade in 1990.

The recent methodology suggested by Greenaway, Hine and Milner for disentangling and investigating the two types of IIT has been refined with the introduction of two innovative features: 1) computation of UV at a deeper level of product disaggregation (8-digit CN level) in order to obtain more reliable indicators of quality differences; 2) more accurate specification of the expected link between vertical intra-industry trade and the specific explanatory variables for quality differentiation (*SKUN* and *KL*).

In accordance with the methodological objections raised in this paper, the regression results have to some extent challenged the robustness of G-H-M's estimates.

Firstly, the unexpected evidence - offered by G-H-M - for the better adaptation of *HIIT* to the small numbers model is not confirmed here. Although the overall explanatory power of *HIIT* estimated equation is not satisfactory, the proxy variable for the market structure (number of firms) has shown a positive and significant coefficient.

Secondly, in contrast to the G-H-M outcome, the specific proxy variable for vertical differentiation (skill intensity) has proved to be negatively related to vertical intra-industry trade. This result is as plausible as a positive link when the dependent variable tested is *VIIT*, a measure of vertical differentiation in trade which does not specify which flow (export or import) embodies superior product quality. As discussed in the previous sections, G-H-M assumed a positive expected link between *VIIT* and *SKUN*, while a more appropriate specification of this relationship implies an ambiguous sign. In effect, when up-market vertical intra-industry trade (*VIITUP*)²⁶ is tested in the place of *VIIT*, the regressions results show a positive sign on *SKUN*. Evidently, this empirical finding is in line with the methodological remarks set out in this paper con-

²⁶ *VIITUP* is the part of *VIIT* in which exports appear upgraded in comparison with imports.

cerning the G-H-M approach to definition of the relationship between product quality and skill intensity. In general terms, this paper suggests that separate testing of the upwards and the downwards components of *VIIT* yields a more accurate interpretation of the sign on *SKUN*, so that the direction of comparative advantage with regard to the quality of goods can be inferred²⁷.

In comparison with G-H-M's estimates, a further specific explanatory variable for vertical differentiation has been introduced into the equation estimated for vertical intra-industry trade. This variable - capital intensity in industry (*KL*) - captures the H-O-type framework suggested by Falvey-Kierzkowski to explain vertical differentiation in trade. For the same methodological reason that was expressed with reference to *SKUN*, the *positive* link between capital intensity and "quality intensity" proposed by Falvey-Kierzkowski can be expected only when *VIITUP* is tested in the place of *VIIT*.²⁸

Finally, the sensitiveness of estimates to the dispersion criterion adopted to discriminate between *HIIT* and *VIIT* has been investigated with regard to the *SKUN* explanatory variable. Contrary to G-H-M's opinion, the impression gained from the sensitiveness analysis is that empirical results are not insensitive to the choice of the dispersion criterion.

²⁷ This methodological suggestion is in line with empirical attempts to explain vertical intra-industry trade through factor proportions in a neo-Heckscher-Ohlin framework. See Torstensson (1991).

²⁸ Under the hypothesis that the observed country is capital-abundant.

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